

## Procedures and Guidelines

**DIRECTIVE NO.** 560-PG-6400.1.1-

**EFFECTIVE DATE:** 10/21/2004

**EXPIRATION DATE:** 10/21/2009

**APPROVED BY Signature:** Original signed by

**NAME:** John Day

**TITLE:** Division Chief

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### **COMPLIANCE IS MANDATORY**

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**Responsible Office:** Code 560/Electrical Engineering Division (EED)

**Title:** GSFC Procedures and Guidelines for Electrostatic Discharge (ESD) Control of ESD-Sensitive (ESDS) Devices

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## **PREFACE**

### **P.1 PURPOSE**

The procedures in this document establish a process of ESD control for all flight hardware, including electrical, electronic, and electromechanical (EEE) parts; mission-support equipment; and elements thereof that may be received, distributed, assembled, disassembled, handled, tested, repaired, or stored at GSFC. These measures apply wherever ESDS devices are present and are required during all phases of receiving, inspecting, assembling, disassembling, cleaning, testing, repairing, packaging, handling, storing, and shipping.

Special requirements may exist that shall not be covered by or shall not be in conformance with the requirements of this document. Engineering documentation shall contain the details for these requirements, and shall take precedence over conflicting portions of this document.

### **P.2 APPLICABILITY**

The procedures and guidelines define the requirements for an ESD Control Plan (ESDCP) for laboratories and work areas that handle flight hardware and EEE parts. These guidelines are intended to provide protection from damage and/or degradation caused by ESD.

### **P.3 AUTHORITY**

[GPG 1280.1, GSFC Quality Manual](#)

### **P.4 REFERENCES**

[ANSI/ESD S20.20-1999, Requirements for Electrostatic Discharge Control Program for Protection of Electrical and Electronic Parts, Assemblies, and Equipment \(Excluding Electrically Initiated Explosive Devices\)](#)

[ESD Prevention for GSFC Hardware](#)

[NASA GSFC Code 560 \(Electrical Engineering Division\) Electrostatic Discharge \(ESD\) Control Plan](#)

## P.5 CANCELLATION

FAP P-303-840, Electrostatic Discharge Control Program

FAP P-303-841, ESD Training Requirements

FAP P-303-842, ESD Facilities Requirements

FAP P-303-843, Audit of ESD

[NASA-STD-8739.7, Requirements for Electrostatic Discharge Control \(ISO 9000\)](#)

**Note:** Although NASA-STD-8739.7 has been canceled; this document is still valid when invoked on contracts established before February 27, 2002.

## P.6 SAFETY

N/A

## P.7 TRAINING

All personnel with access to ESD-controlled laboratories and work areas that handle, package, store, test, or transport ESDS devices shall be trained and certified in accordance with ANSI/ESD S20.20-1999. ESD certification classes are offered through the [NASA Manufacturing Technology Transfer Center \(NMTTC\)](#) or another facility that is NASA certified to instruct in ESD protocols.

## P.8 RECORDS

Quality Records	Records Custodians	Retention
ESD Control Plan	Assigned ESD Custodian/Lead	Retain for 5 years.
Training Records	Assigned ESD Custodian/Lead	Retain for 5 years.
Work Area/Laboratory Certification Records	Assigned ESD Custodian/Lead	Retain for 5 years.
Self and Independent Audit Records	Assigned ESD Custodian/Lead	Retain for 5 years.
ESD Audit Workstation Sheet*	Assigned ESD Custodian/Lead	Retain for 5 years.

\*See Figure 1 for a typical ESD Audit Workstation Sheet. Temperature, relative humidity, grounding (personnel and workstations), and discharge events of ESDS areas shall be monitored, recorded, and archived when ESDS parts or assemblies are exposed to the ambient environment.

## P.9 METRICS

The number of cumulative and individual incidences in which temperature, relative humidity, grounding (personnel and workstations), and discharge events that exceed set boundaries shall be reported quarterly.

## P.10 DEFINITIONS

- a. Assembly – A functional subdivision of a component consisting of parts or subassemblies that perform functions necessary for the operation of the component as a whole. Examples: regulator assembly, power amplifier assembly, and gyro assembly.
- b. Certification – The act of verifying and documenting that personnel have completed required training, demonstrated specified proficiency, and met specified requirements.
- c. Component – A functional subdivision of a system, generally a self-contained combination of assemblies performing a function necessary for the system's operation. Examples include power supply, transmitter, and gyro package.
- d. Conductive Material – ESD-protective material having a surface resistivity of less than  $10^4$  ohms per unit square.
- e. Control Area – An area that is constructed and equipped with the necessary ESD-protective materials and equipment to limit ESD voltage below the sensitivity level of the ESD devices that are handled therein. The ESD-controlled areas shall be labeled as such.
- f. Electrical Discharge (ED) – An instantaneous transfer of electrical power. Examples include a lightning strike or a large current spike when power is applied to a large inductive power source, such as building power supplies, magnetic motors, or small current spikes when load-high current of high-voltage power supplies used for test equipment turns on.
- g. Electrostatic Charge – An electric charge on the surface of an object.
- h. Electrostatic Discharge – A transfer of electrostatic charge between bodies at different electrostatic potentials caused by direct contact or induced by an electrostatic field.
- i. ESDS Devices – Electronic parts (microcircuits, semiconductors, hybrids, etc.), subassemblies, assemblies, components, and subsystems of a flight hardware package or related equipment that may be damaged or the performance degraded by exposure to ESD.
- j. Ground – A mass such as Earth or a vehicle hull capable of supplying or accepting a large electrical charge.
- k. Ground Fault Circuit Interrupter – A sensing device in series between electrical equipment and the electrical power source. The functions of the device are to sense leakage currents in faulty equipment, sense higher than normal rated currents for the circuit, and interrupt (break) the electrical circuit.
- l. Ground Strap – A resistive (skin contact) wrist, leg, or ankle strap that is designed to dissipate personnel static charge quickly and safely.

- m. Hard Ground – A connection to ground either directly or through low impedance (<100 ohms).
- n. Soft Ground – A connection to ground through impedance sufficiently high to limit current flow to safe levels for personnel (normally 5 milliamperes). Impedance needed for a soft ground is dependent upon the voltage levels that could be contacted by personnel near the ground.
- o. Handle or Handling – Actions in which devices are hand-manipulated or machine-processed during actions such as inspecting, manufacturing, assembling, cleaning, staging, testing, repairing, reworking, maintaining, installing, transporting, failure analyzing, wrapping, packaging, marking, or labeling.
- p. Induction Polarization Charge (IPC) – The attracting or repelling of electrons on the surface of an object (e.g., circuit board) when the electrostatic field of a highly charged material (e.g., Styrofoam cup) is placed on or moved close to the object.
- q. Insulating Material – Material having surface resistivity greater than or equal to  $10^{11}$  ohms per unit square.
- r. Part – An element of a component, assembly, or subassembly that is not normally subject to further subdivision or disassembly without destruction of designed use.
- s. Protected Material – Material capable of one or more of the following characteristics: limiting the generation of static electricity, safely dissipating electrostatic charges over its surface or volume, or providing shielding from ESD spark discharge or electrostatic fields.
- t. Protective Handling – Handling of ESDS devices in a manner to prevent damage from ESD.
- u. Static Dissipating Material – ESD-protective material that has a surface resistivity greater than or equal to  $10^4$  ohms but less than  $10^{11}$  ohms per unit square.
- v. Surface Resistivity – An inverse measure of the conductivity of a material equal to the ratio of the potential gradient to the current per unit width of the surface, where the potential gradient is measured in the direction of the current flow in the material.
- w. Triboelectric Charge – A surface-generated positive or negative charge formed when two similar or dissimilar materials are rubbed together or separated from each other.
- x. Work Station – A non-static-generating workbench, table, platform, etc. where ESD devices are handled in an ESD-controlled area.

## PROCEDURES

In this document, a requirement is identified by “shall,” a good practice by “should,” permission by “may” or “can,” expectation by “will,” and descriptive material by “is.”

The procedures cited below shall be followed:

- An ESD Officer shall be appointed within EED.
- The ESD Officer shall establish, maintain, and monitor metrics on all ESDS areas within EED.
- The Branch/Office Head shall appoint an ESD Custodian/Lead to take responsibility of ESD operations for each ESDS lab/work area within their respective branch/office.
- The ESD Custodian/Lead shall establish and implement the ESD procedures and guidelines at the respective laboratory sites, board-level assembly areas, and integration bay areas.
- The ESD Custodian/Lead shall be responsible for the following actions that shall control the ESD program operations at the respective sites:
  - a. Establish an ESD Control Program, using the NASA GSFC Code 560 EED (Electrical Engineering Division) ESD Control Plan (maintained by Code 562), which covers procedures, guidelines, and equipment for conformance to the applicable work area.
  - b. Where required by the EED ESD Control Plan, certify the adequacy of ESD-controlled areas for space flight hardware (e.g., conductive flooring and grounded stations) prior to their use in accordance with ANSI/ESD S20.20-1999 by certified ESD audit.
  - c. Clearly identify all ESD-controlled areas for space flight hardware by prominently placed signs. A partition, rope guard, or similar means shall be set up to assist in prohibiting unauthorized and untrained personnel from entering an ESD-protected area. ESD precautionary signs can be found on the ESD Website ([http://eed.gsfc.nasa.gov/562/ESD\\_BestPractices.htm](http://eed.gsfc.nasa.gov/562/ESD_BestPractices.htm)) under ESD Equipment and Supplies.
  - d. Train and certify all personnel with access to ESD-controlled areas who handle, test, package, store, or transport ESDS devices in accordance with ANSI/ESD S20.20-1999. For personnel with access to ESD-controlled areas who do not function in the above capacities, training in the basics of ESD prevention is necessary. These personnel shall be escorted by ESD-certified personnel and made aware of ESD requirements when in ESD-controlled areas.
  - e. Ensure that flight ESDS parts and assemblies shall be handled only in certified ESD-protected Class I areas and accordance with ANSI/ESD-S20.20-1999. Outside ESD-protected areas, ESDS items shall be enclosed in ESD-protective packaging.

- f. Ensure that self-audits and inspections of ESD-protected areas (see Table 1) shall be done on a periodic basis. Self-audit and inspection reports shall include date of audit or inspection, performing personnel, requirements audited, documented results, and recommended corrective action if needed.
- g. Maintain internal reports and audit records. Archive records should be delivered along with end-product assembly where appropriate.
- h. Ensure that all deficiencies noted during audits or certification shall initiate corrective actions.
- i. Ensure that the relative humidity levels are maintained in ESD-protected areas at an ideal range of 40% to 60% and a maximum range of 30% to 70% (see note under humidification in NASA-STD-8739.7, page 7-5). All ESD-protected areas shall monitor temperature and relative humidity levels. At levels below 40%, additional precautions shall be employed (e.g., air ionizers and humidifiers). If other precautionary methods are not available, work shall be halted until the required humidity level is obtained.
- j. Ensure that materials approved for use within ESD-protected areas, such as protective gloves for example, shall be documented in an ESD-protective approved materials list.
- k. Consider ALL EEE parts, boards, and assemblies that are received, inspected, assembled, disassembled, cleaned, tested, repaired, packaged, handled, stored, and shipped to be ESD sensitive.
- l. Ensure the use of protective personnel clothing and proper personnel grounding (such as wrist straps, finger cots, etc.) are at all locations where ESD devices are handled.
- m. When appropriate, it is recommended that ESD paper and covers be used near ESDS devices. If standard paper is used, keep paper at least three (3) feet away from ESDS devices.
- n. Ensure that any flight ESDS part or assembly is at least three (3) feet from the nearest CRT monitor.
- o. Verify that proper ESD marking labels, precautions, and handling procedures are in place on any type of packaging containing ESDS devices, printed circuit boards, or flight-ready hardware with mounted ESDS devices.
- p. Ensure that ESDS purchasing documentation includes ESD requirements.

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**Table 1.** ESD Certification and Periodic Audit/Inspection Schedule


Subject	Prior to Use	Continuous	Each Work Shift	Weekly	Monthly	Quarterly	Semiannually	Annually
ESD Surface Resistivity and Mats	X				X <u>2/</u>			
Work Surface Grounding	X				X <u>2/</u>			
Work Surface Solvent Resistance	X							X
Conductive Floor Resistivity	X				X <u>2/</u>			
Wrist Strap Resistance	X		X					
Foot Grounding Device Integrity	X		X					
Cart, Wagon, and Tram Grounding	X						X	
Air Ionizer	X				X			
Stool and Chair Grounding	X						X	
Tool and Equipment Grounding	X				X			
Self Audit						X		
Personnel Garments	X		X					
Work Surface Static Charge Dissipation	X						X	
Wrist Strap Continuity	X		X <u>1/</u>					
Humidity (RH)	X	X						
Facility Earth Grounding	X				X			
Temperature Chambers	X							X
Soldering Iron Tip Grounding	X			X				

1/ Continuous monitoring system can be substituted per ANSI/ESD S20.20-1999.

2/ Monthly recertification can be substituted to semiannually recertification per waiver request by the project.

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 <b>MONTHLY ESD WORKSTATION VERIFICATION SHEET</b>						
WORKSTATION ID NUMBER: _____						
<i>All measurements to be performed monthly unless otherwise indicated</i>						
	DATE: _____		DATE: _____		DATE: _____	
	Pass/Fail	Data	Pass/Fail	Data	Pass/Fail	Data
<b>TEST ITEM</b>						
Work Area Relative Humidity (Within 40 to 60%)						
Work Surface Resistivity (Within $10^5$ to $10^9$ ohms sq.)						
Work Surface Grounding (1 megohm +/- 20%)						
Continuous Monitor Cal Status (Within calibration cycle)						
Cleanliness (Area to be clear of extraneous materials)						
Workstation Status** (Approved/not approved)						
Operator Signature						

**Figure 1.** Typical ESD Audit Workstation Sheet



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### CHANGE HISTORY LOG

Revision	Effective Date	Description of Changes
Baseline	10/21/2004	Initial Release

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